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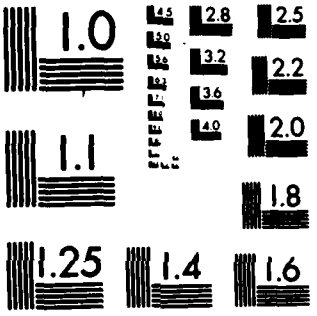

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20. Abstract The objective of this contract was to prepare a profiled film of the Barr and Stroud diamond-like carbon coatings on germanium substrates. This report describes the techniques used to prepare the films and the results of optical measurements. The samples have been supplied to the US Government for further optical and environmental analysis.		

FORM 1473

PREPARATION OF A PROFILED FILM OF DIAMOND-LIKE CARBON ON GERMANIUM SUBSTRATES

Report of Results for USAF Contract F49620-83-C-0112DEF

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1. SUMMARY

The objective of this contract was to prepare a profiled film of the Barr and Stroud diamond-like carbon coating on five germanium substrates. The profile of the film was to be in accordance with Figure 1 and the substrates coated on one face. The specification of the substrates used is listed in Table 1.

This report describes the techniques used to prepare the films and the results of optical measurements on the samples.

2. DEPOSITION TECHNIQUE

A masking technique was developed specifically to prepare profiled films for this contract. The construction of the mask is illustrated in Figure 2. The mask was cut from $^{3}/_{1000}$" thick molybdenum sheet using a spark erosion technique to avoid any sharp edges which could damage the substrate surface. The mask could slide in a groove machined in an aluminium holder and was retained in position by two thin aluminium strips. In the middle of the electrode was a hole for the substrate. Shims of molybdenum were used to adjust the height of the substrate so that its upper surface was level with the lower surface of the mask. The complete structure was firmly bolted to the RF electrode of a sputtering unit. The position of the maks was adjusted from outside the vacuum system with a linear motion vacuum feedthrough acting via an insulated rod against a bracket on the mask.

The deposition technique and conditions for the coating are proprietary to Barr and Stroud and confidential. The thickness of the films was controlled by measuring the time of the deposition while keeping the deposition conditions constant (e.g. pressure, gas flow rate, RF power, bias voltage, etc). A series of tests was performed to obtain a calibration curve of thickness against time.

Each substrate was cleaned by hand using an optical handkerchief and iso-propyl alcohol. In addition the substrates were cleaned for about 15 minutes using an argon discharge with the mask in the position which exposed the complete substrate. Immediately after the argon discharge clean the mask was moved to its second position where all but the area to be uncoated was exposed and $\lambda/4$ of the coating was deposited ($\lambda = 3.8\mu m$). The mask was then moved about $^3/_8$" and a further $\lambda/4$ deposited. This was repeated a further two times. In order to ensure good adhesion of the coating and consistent deposition rates, the discharge was not interrupted from the start of the argon clean to the completion of the coating.

3. RESULTS OF MEASUREMENTS

Witness pieces were subjected to a number of durability tests and the results are summarised in Table 2.

The transmission of each step of every sample was measured using a Fourier Transform Infra-red Spectrometer. The transmission of a typical sample is illustrated in Figures 3, 4, 5 and 6. The estimated optical thickness for each sample is summarised in Table 3 along with the target values.

4. CONCLUSION

Five germanium substrates have been successfully coated with a profiled film of diamond-like carbon to the requested specification within experimental limits.

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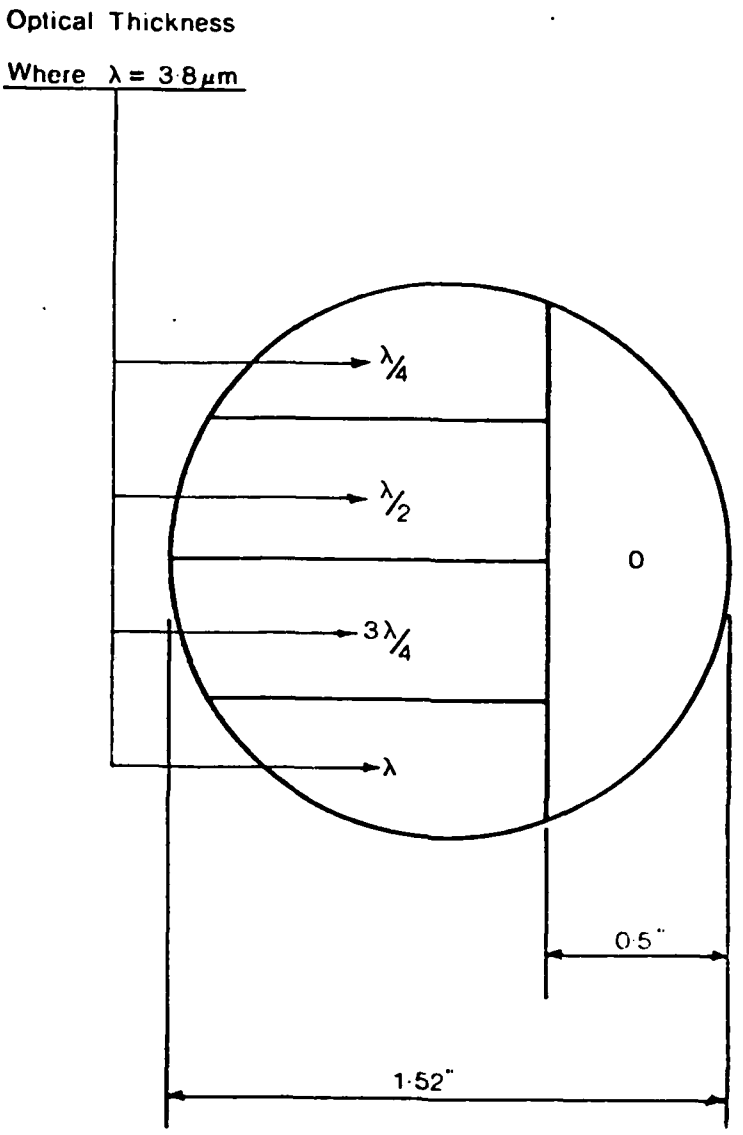
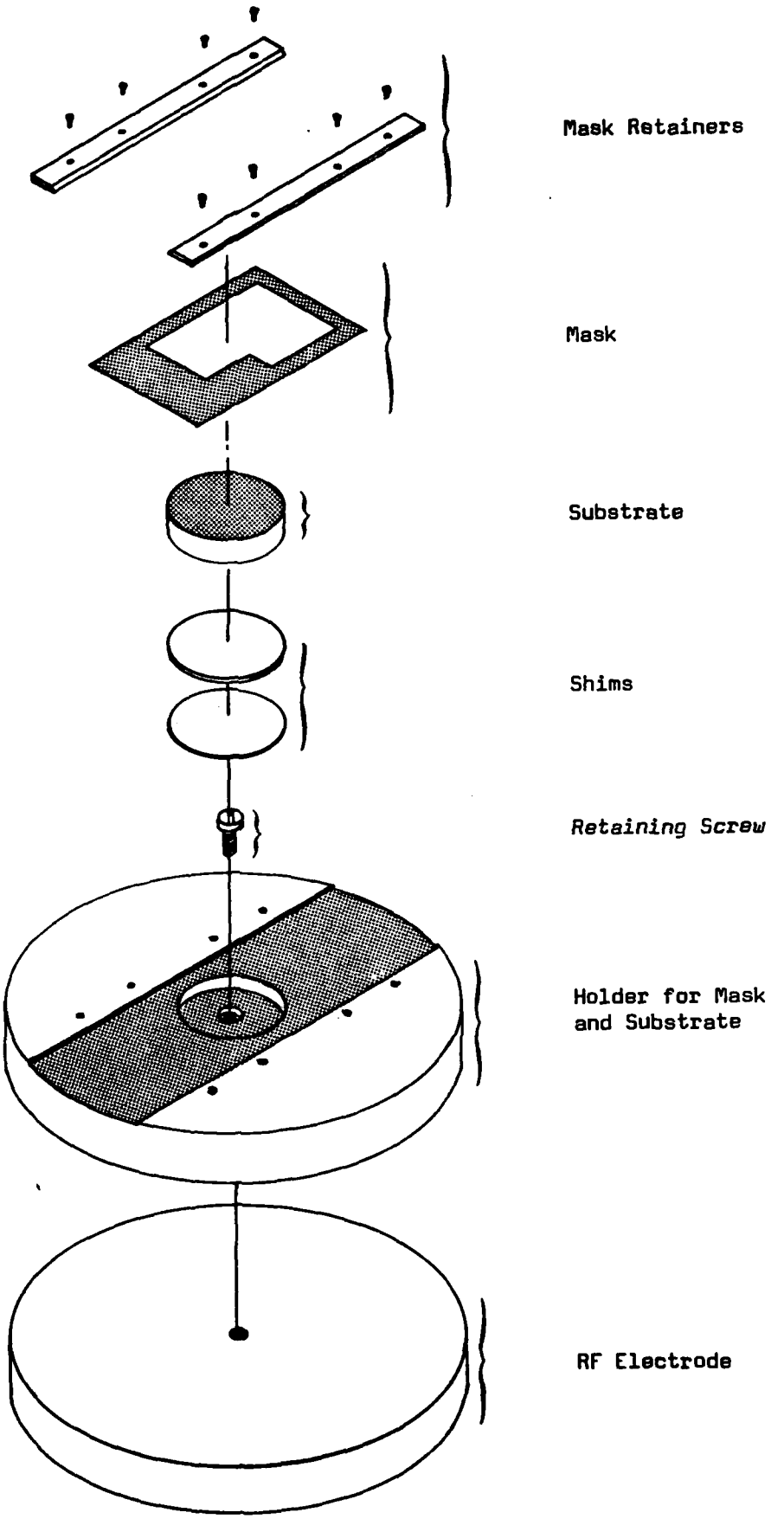


FIGURE 1

GEOMETRY OF ARG 4 FILM
(TARGET)



MASKING ARRANGEMENT

FIGURE 2

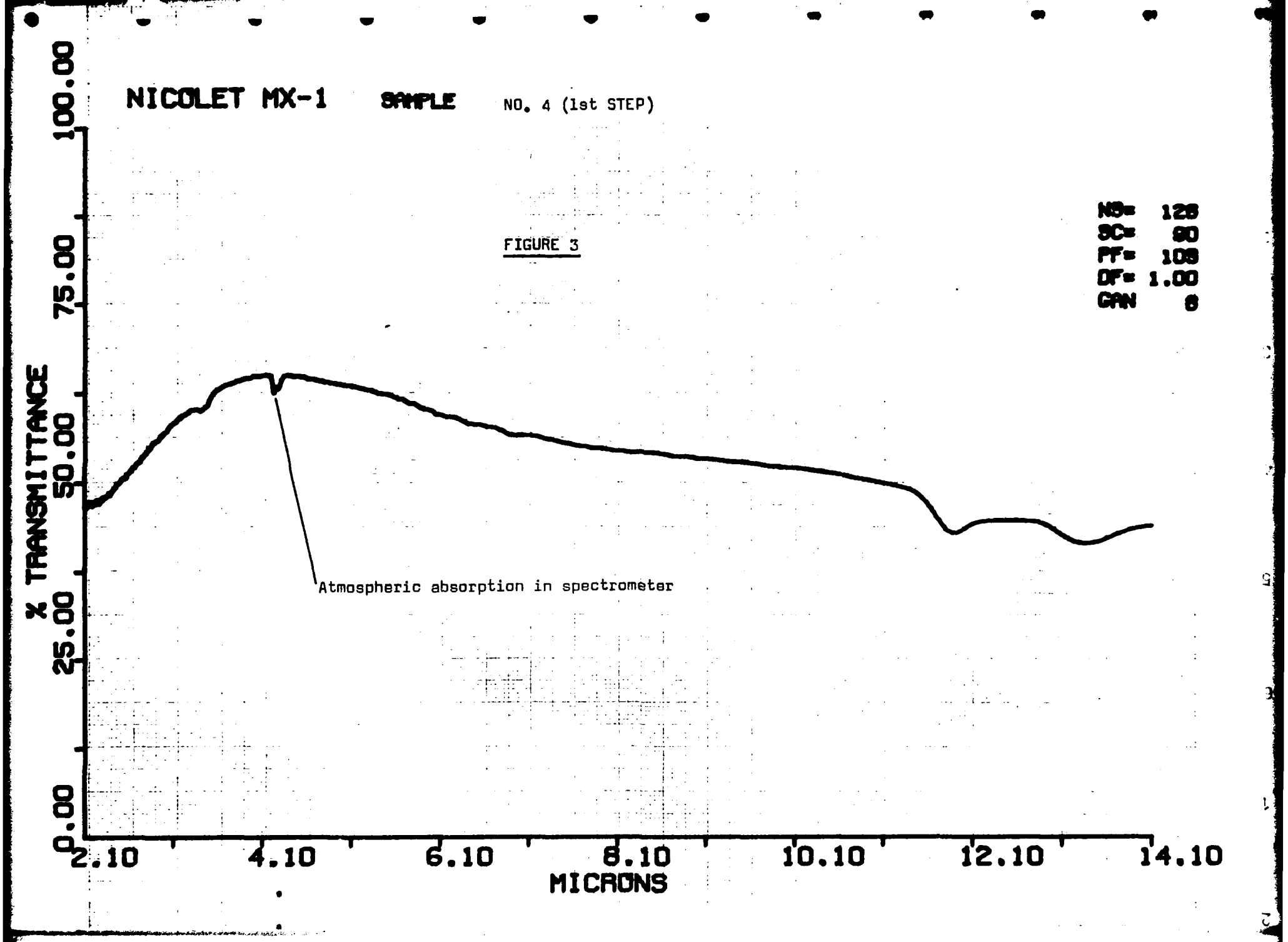
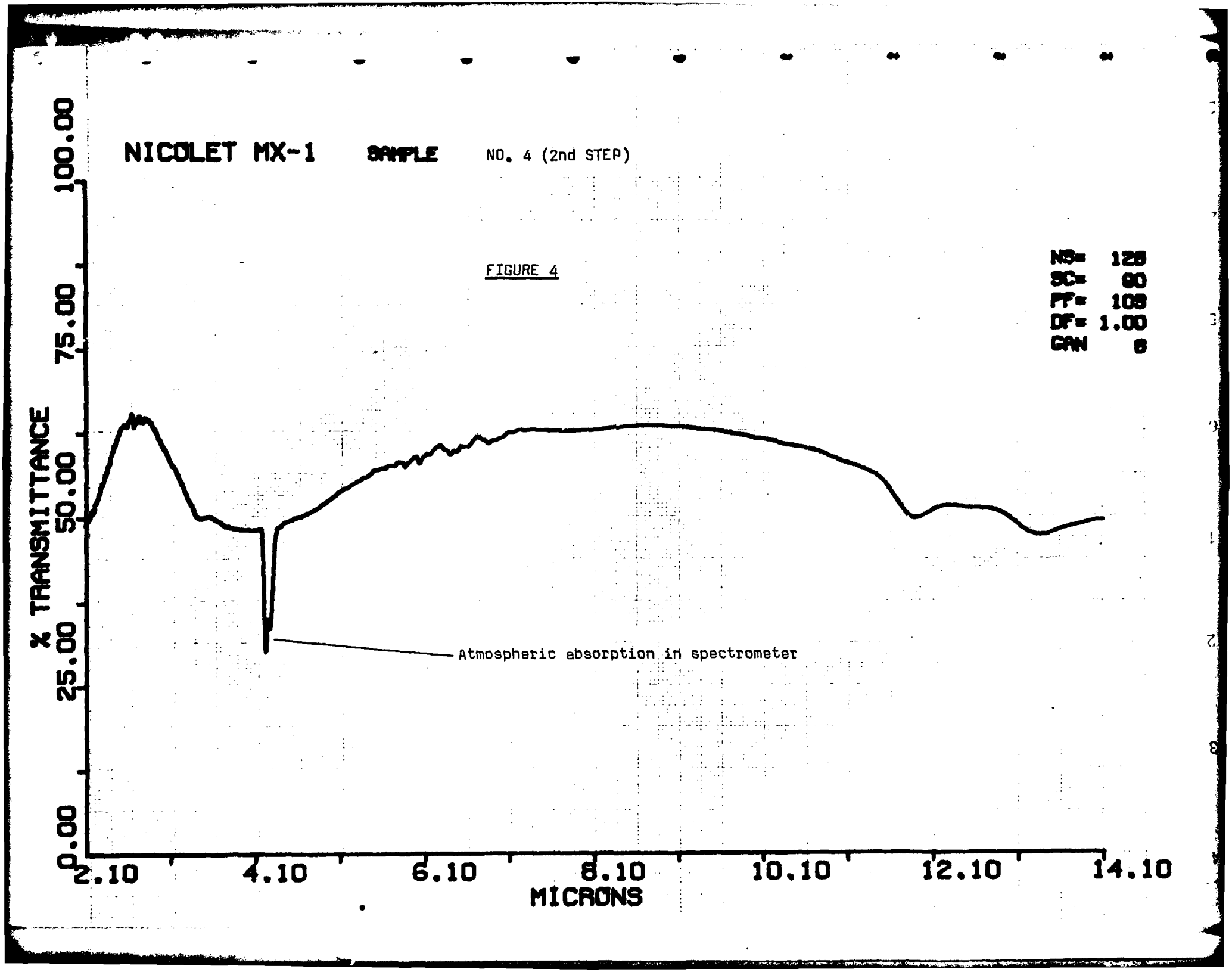

NICOLET MX-1 SAMPLE NO. 4 (1st STEP)
NS= 128
SC= 80
FF= 108
DF= 1.00
GAN 8
100.00
75.00
50.00
25.00
0.00
% TRANSMITTANCE
Atmospheric absorption in spectrometer
2.10
4.10
6.10
8.10
10.10
12.10
14.10
MICRONS

FIGURE 3


NICOLET MX-1 SAMPLE NO. 4 (2nd STEP)
FIGURE 4
NS= 128
SC= 98
FF= 100
DF= 1.00
GAN 8
100.00
75.00
50.00
25.00
0.00
% TRANSMITTANCE
Atmospheric absorption in spectrometer
2.10
4.10
6.10
8.10
10.10
12.10
14.10
MICRONS

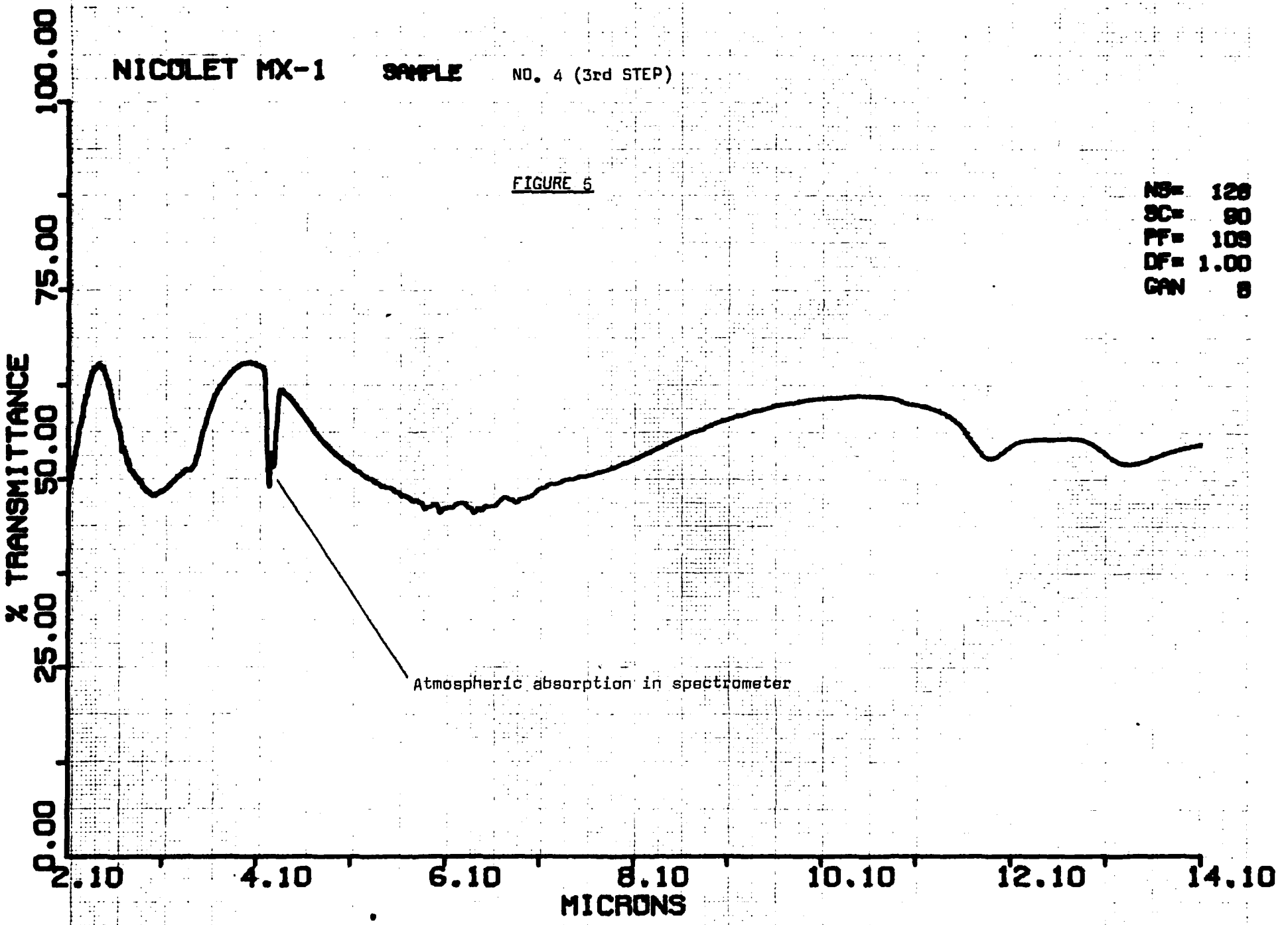
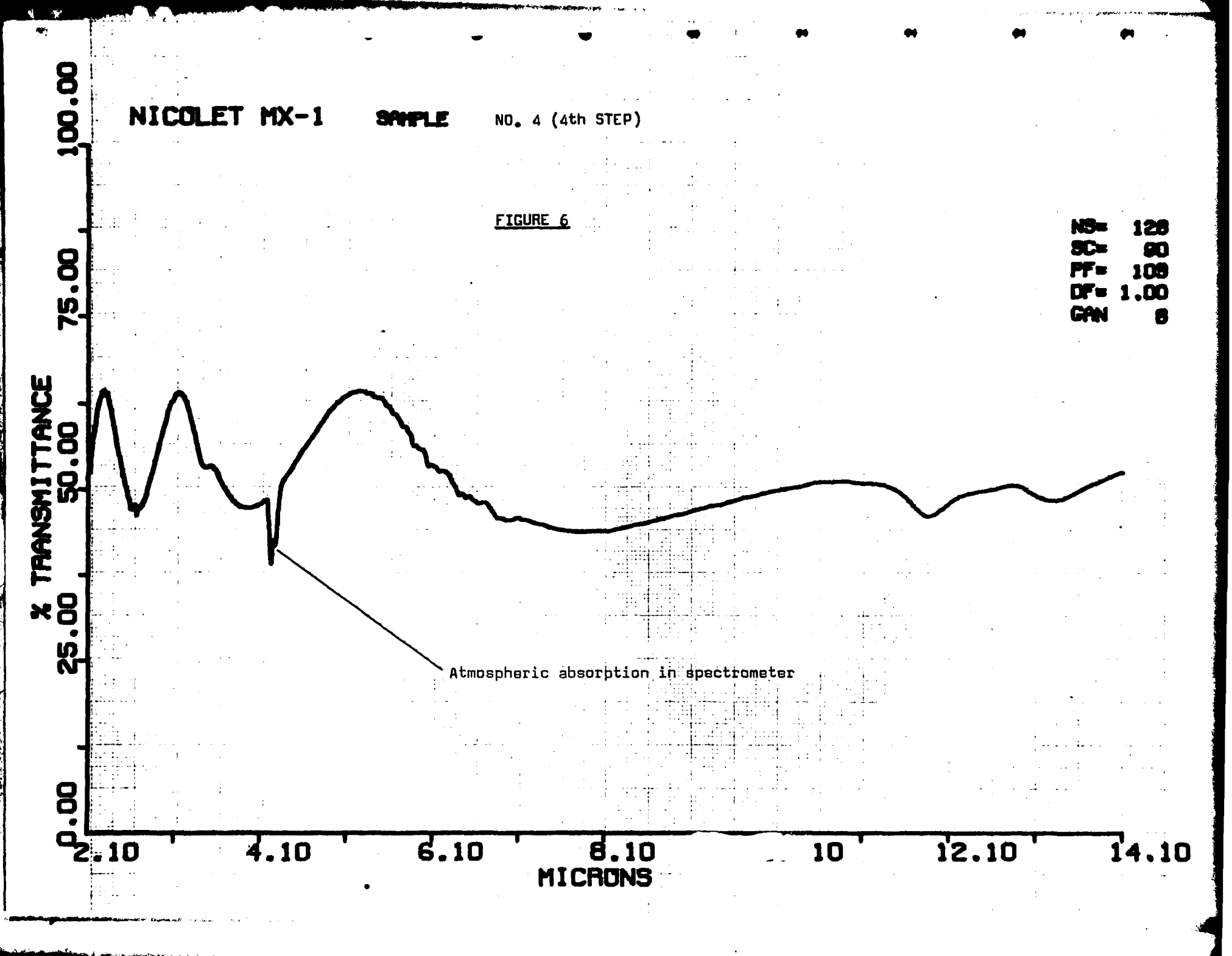

NICOLET MX-1 SAMPLE NO. 4 (3rd STEP)
NS= 128
SC= 90
FF= 105
DF= 1.00
GAN 8
100.00
75.00
50.00
25.00
0.00
% TRANSMITTANCE
2.10
4.10
6.10
8.10
10.10
12.10
14.10
MICRONS
Atmospheric absorption in spectrometer

FIGURE 5


NICOLET MX-1 SAMPLE NO. 4 (4th STEP)
FIGURE 6
NS= 128
SC= 80
FF= 108
DF= 1.00
GAN 8
% TRANSMITTANCE
100.00
75.00
50.00
25.00
0.00
2.10
4.10
6.10
8.10
10
12.10
14.10
MICRONS
Atmospheric absorption in spectrometer

SPECIFICATION FOR SUBSTRATES

1)	Diameter	$1.52" \begin{smallmatrix} + 0.000" \\ - 0.005" \end{smallmatrix}$
2)	Thickness	0.25 - 0.375"
3)	Flatness	2 fringes visible or better
4)	Parallelism	30 sec of arc or better

TABLE 1

RESULTS OF DURABILITY TESTS ON WITNESS PIECES

Test	Relevant Specification	Witness Piece 1 (Optical thickness $\lambda/4$ where $\lambda = 3.2\mu m$)	Witness Piece 2 (Optical thickness $\lambda/4$ where $\lambda = 15.9\mu m$)
Abrasion	MIL-C-675A para 4.6.11	pass	pass
Adhesion	MIL-M-13508B para 4.4.6	pass	pass
Salt Solution	MIL-C-675A para 4.6.8	pass	pass
Wiper Action	(see below)	pass	pass

Wiper Action: Coatings subjected to 10,000 wipes with a windscreen blade loaded to 20 grams and operating with a sand/water mixture to DEF STAN 07-55 Type C without measurable deterioration.

TABLE 2

ESTIMATED OPTICAL THICKNESS OF EACH STEP

	Optical thickness in $\lambda/4$ where $\lambda = 3.8\mu m$			
	Step 1	Step 2	Step 3	Step 4
Target Values	1.00	2.00	3.00	4.00
Sample 1	1.16	2.21	3.16	4.21
Sample 2	1.11	2.13	3.03	3.84
Sample 3	1.11	2.03	3.03	3.89
Sample 4	1.08	2.08	3.03	4.00
Sample 5	1.24	2.13	3.05	3.95

TABLE 3